Application and verification of ECMWF products 2015 at the Finnish Meteorological Institute

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1. Summary of major highlights

This kind of feedback report often turns into problem report and therefore it should be mentioned already in the beginning that we are generally quite satisfied with ECMWF model and products. We are also looking forward for coming big updates in the near future.

As a summary, we would like to raise two challenges. First one is highlighted because the problem has been persisting now for several years and the other one because of its severity:

- Negative bias in evening temperature (including EPS), especially in spring time (see chapter 3.1.1).
- Case “windstorm” on 23 May 2015 (see chapter 3.2.2.). The ECMWF model output (including EPS) didn’t give a clear signal for violent wind gusts until 12-24h before the event.

2. Use and application of products

FMI’s medium and long range weather forecasts are strongly based on ECMWF deterministic and ENS products. ECMWF data is also utilised as boundary conditions for HIRLAM/HARMONIE which are run at FMI. Usage and demand of monthly and seasonal forecasts is slowly increasing by energy customers, media and general public. ECMWF monthly and seasonal products have a crucial role in long range forecast production although some other sources are also used.

2.1 Post-processing of ECMWF model output

Manual editing done by forecasters (by choosing different model and making needed adjustments to model) plays a crucial role in our production system concerning forecasts in Finland and Scandinavia. Forecasts for foreign countries are not manually edited and thus fully automatic and they are based ECMWF raw 2m temperature forecasts which are calibrated by height correction and land-see interpolation.. At the moment, FMI is strongly developing statistical calibration and post-processing systems. At the moment, ECMWF 2m temperature forecasts are operationally calibrated by Kalman filtering in Scandinavia and Kalman filtered data is used more frequently among duty weather forecasters. Post-processing is also done to improve wind gust forecasts. FMI also uses ECMWF data to calculate some new weather parameters that model doesn’t provide by itself for example precipitation form, probability of thunder and probability of precipitation.

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2.2 Use of ECMWF products

Majority of FMI’s own numerical weather weather prediction is based on ECMWF data. ECMWF provides input for various applications like limited area models (HIRLAM, HARMONIE), dispersion and trajectory models, hydrological models (run by Finnish Environmental Institute), road condition models and wave models.

3. Verification of products

3.1 Objective verification

The quality of FMI’s weather forecasts are systematically validated and official scores reported to the ministry of transport are T2m forecast hit rate for one day and 2-5 days, predictability of precipitation based on SEEPS score and verification of wind warnings based on ROC. Besides the official scores, verification data from different data sources is widely used by weather forecasters. For instance, forecasters can easily find both near real time verification results or longer term verification scores and time series. FMI´s verification interface gives a possibility to assess the quality of different model data and further, compare different data sources with each other.

3.1.1 Direct ECMWF model output (both HRES and ENS)

ECMWF 2m temperature forecasts have a negative bias in spring time, especially during evening hours(fig 1.). This has been a long-standing challenge for several years which has also been noticed by end users. For example, Finnish Environmental Institute (SYKE) uses ECMWF products in their hydrological models to calculate flood risks. During spring time, when snow is melting, too cold evening temperatures significantly underestimates flood probabilities. This same problem exists also in EPS forecasts (fig 2.). In fig 2. it is also seen, that problem exists also during summertime.

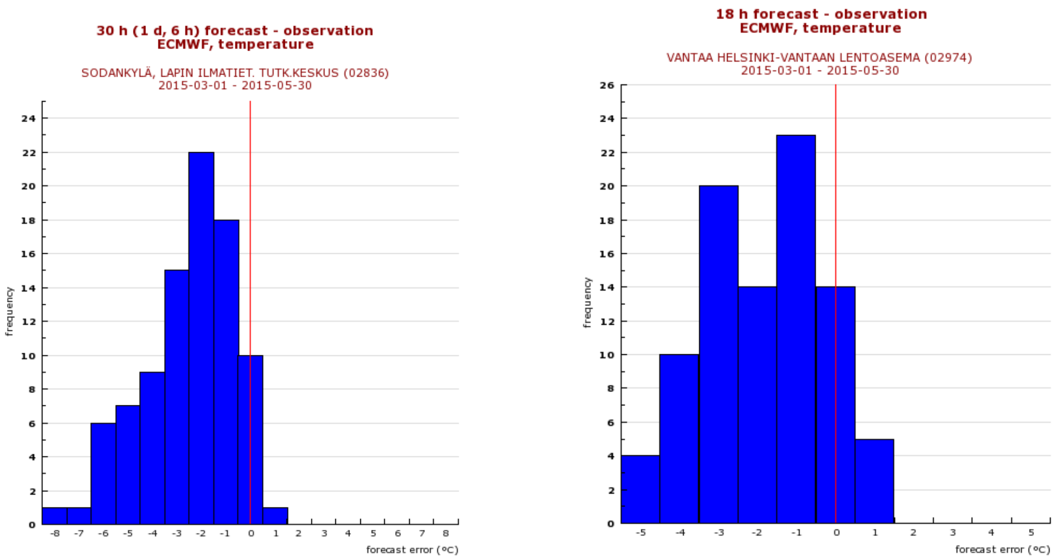

Figure 1. BIAS in evening temperatures (T2m) in ECMWF in spring
(data in these pics from 1.3.2015-30.5.2015).
Left: Histogram of ECMWF forecast error of 2m temperature of 12 UTC model runs in Sodankylä during MAM 2015 (forecast lead time 30 hours)
Right: Histogram of ECMWF forecast error of 2m temperature of 00 UTC model runs in Helsinki-Vantaa airport during MAM 2015 (forecast lead time 18 hours).

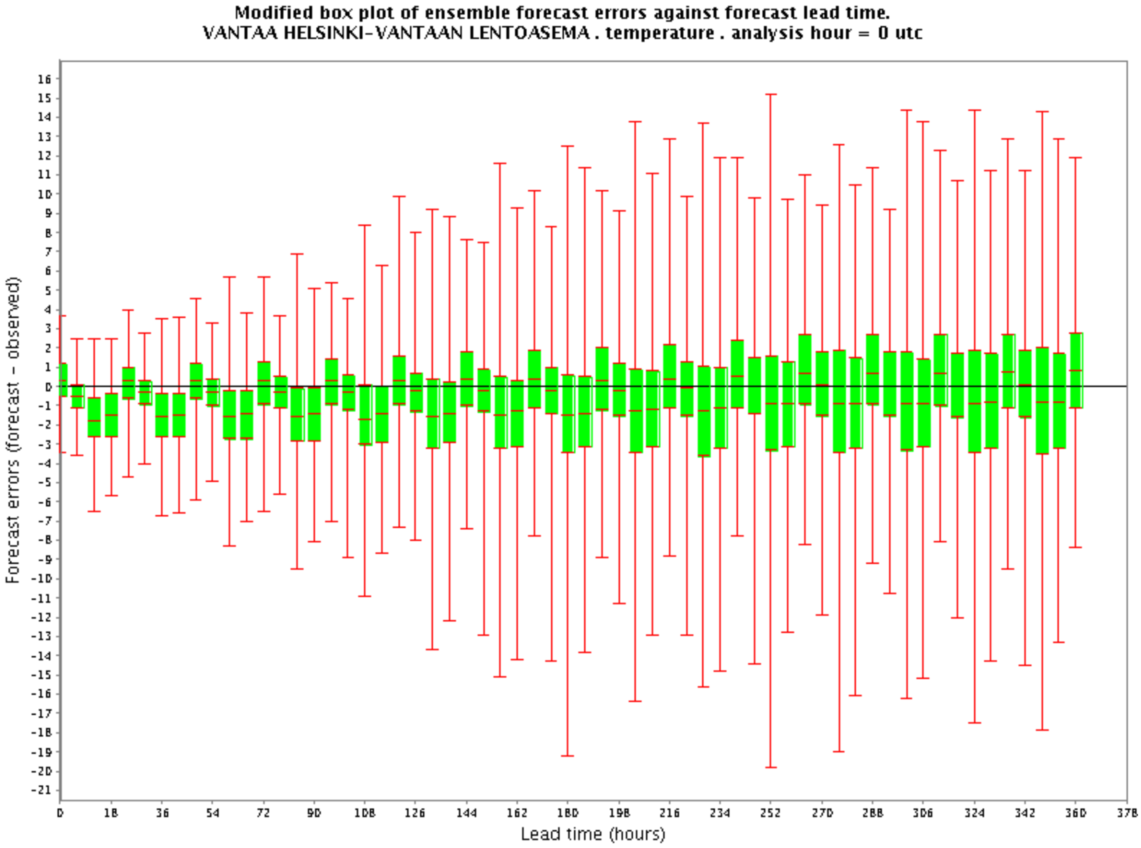

Figure 2. Forecast error in EPS temperature forecasts (T2m) in Helsinki-Vantaa airport in 5.5.2015-23.8.2015.

Some comments concerning ECMWF monthly and seasonal forecasts:

The seasonal forecasting system (System4) has had difficulties in predicting (the few) negative temperature anomalies in Finland, but has been more successful in predicting positive temperature anomalies. In addition, there still seems to be too many "no signal" forecasts when compared to the observed anomalies. ECMWF seasonal forecasts related to observation in Helsinki are shown in table 1

Helsinki-Kaisaniemi observation

Forecast ΔT	≥ 0.5 °C	-0.4…0.4 °C	≤ -0.5 °C	sum
≥ 0.5 °C	13	5	3	21
-0.4…0.4 °C ("no signal")	15	5	3	23
≤ -0.5 °C	1	0	0	1
sum	29	10	6	45

Table 1.ECMWF seasonal forecasts (system 4), 3 month temperature anomaly forecasts (ensemble mean) for Helsinki (45 cases), verified against observed anomalies from Kaisaniemi observation site (in the city centre). 18/45 (40%) of the cases on the "diagonal".

3.1.2 ECMWF model output compared to other NWP models

Mostly used weather models at FMI are ECMWF, HIRLAM and HARMONIE, but also Kalman filtered T2m from ECMWF and EPS fractiles for some parameters are quite often used. Evening bias in spring, mentioned in chapter 3.1.1., is the biggest in ECMWF if we compare the different data sources with each other(see fig. 3).

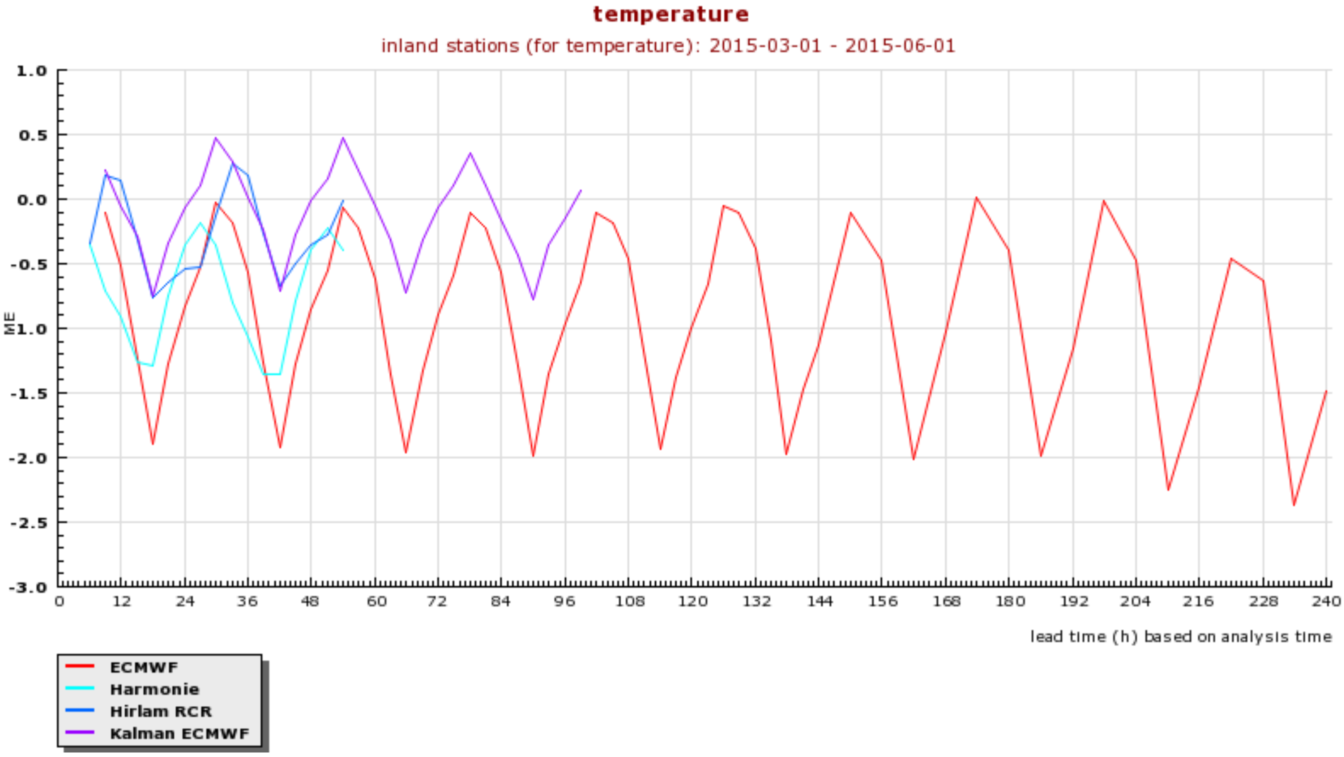

Figure 3. Temperature forecast mean error in spring (MAM) 2015 by different models (ECMWF, HARMONIE, HARMONIE KalmanEC). Evening BIAS, mentioned in chapter 3.1.1. is the biggest in ECMWF.

3.2 Subjective verification

Some comments from FMI´s on duty forecasters:

- ECMWF is quite good in forecasting larger stratus clouds, but when it comes to more local stratus clouds HIRLAM is better. ECMWF seems to have drier boundary layer than HIRLAM and usually HIRLAM-forecast is better.
- Once in a while ECMWF has problems forecasting ground inversion.. This is a problem when making decisions whether to forecast icing or not. HIRLAM has been better in these cases. In many cases HIRLAM has had the inversion so that there exists layer of degrees above zero giving possibility to snow to melt and cause ice when hitting the ground. ECMWF has had in these cases thinner inversion layer and layer not reaching degrees above zero.
- Sea ice analysis error has caused problems when forecasting temperatures. The ECMWF analysis contained ice on southern Bay of Bothnia even though in reality ice has melted already long time ago (see fig 4). Accordingly, the predicted temperatures near to sea were over 5 degrees too low. The errors were also shifted to FMI’s high resolution model HARMONIE (which gets its background information from the ECMWF).

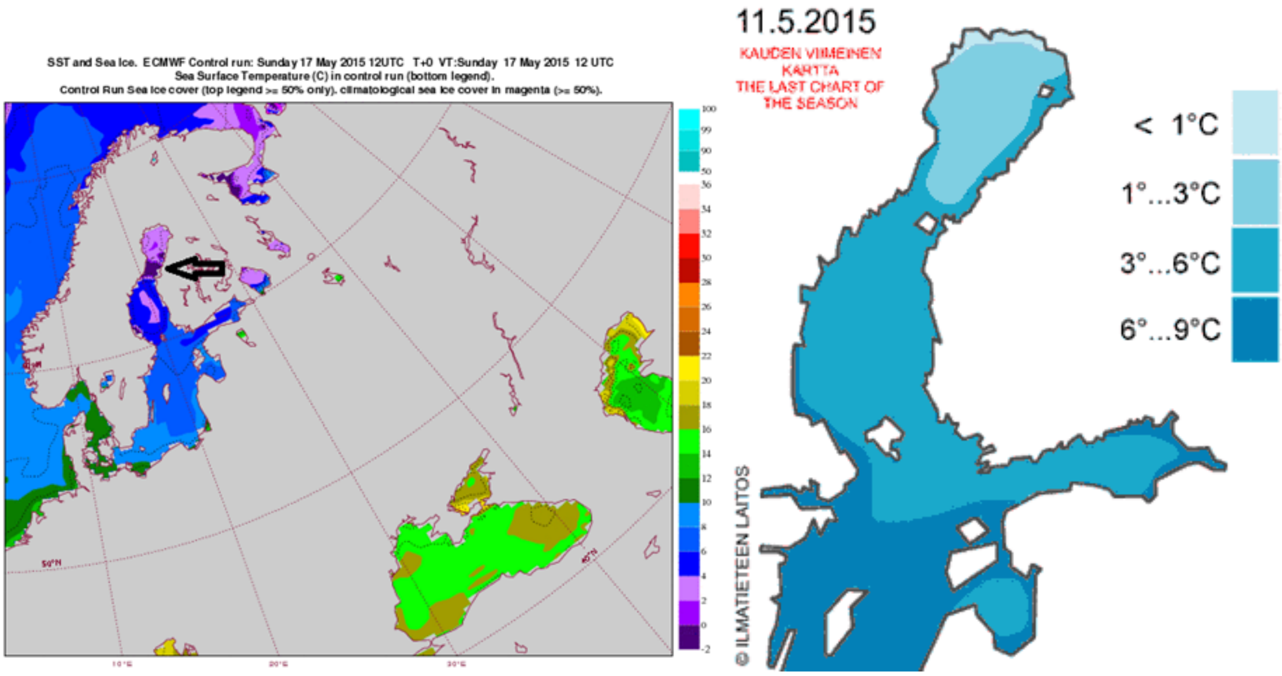

Figure 4. Left: SST and Sea ice in ECMWF 17 May 2015 12 UTC
Right: Observed SST 11 May 2015

- Concerning northern Finland ECMWF is better than HIRLAM in northwesterly flow situations.
- Two meter temperatures tend to be too low in ECMWF over snow-covered ground. This problem exists especially in Lapland later in spring when sun is already warming and snow cover is still unbroken.
- Over larger lakes, where model gridpoints exist, ECMWF is too cold. Besides that, the model spreads the coldness also to areas around the lake. Problem exists especially around lake Ladoga.
- During high pressure period in August 2015 ECMWF was too warm in the night time and too cold in daytime. Kalman filtered ECMWF was somewhat better in that situation and HIRLAM was the best model in this case. One example from Tampere-Pirkkala-Airport is seen in fig 5.

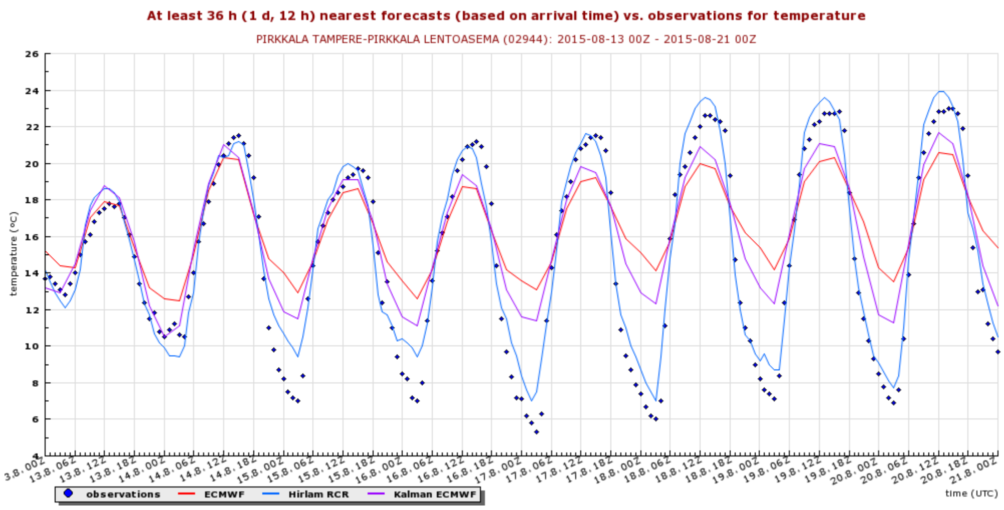

Figure 5. Forecasted temperature (2m) with forecast lead time 36 h in Tampere-Pirkkala airport. Red curve ECMWF, violet curve KalmanEC, blue curve HIRLAM and the dots are the observations. Time period in this fig.13.8.2015-21.8.2015.

3.2.2 Case studies

"Windstorm" on 23 May 2015:

A deepening center of low pressure moved over Northern Finland to northeast. Abruptly intensified southwesterly winds caused damage in many places in Central Finland and the Emergency Response Center received hundreds of wind-related emergency calls. Maximum wind gusts were 20-26, locally up to 30 m/s. The ECMWF model output (including EPS) didn't give a clear signal for violent wind gusts until 12-24h before the event (and neither did the GLAMEPS). The NWP data which was available during the night preceding the event showed a mixed signal. However, the majority of the models failed to forecast severe wind gusts. See figures 6-8.

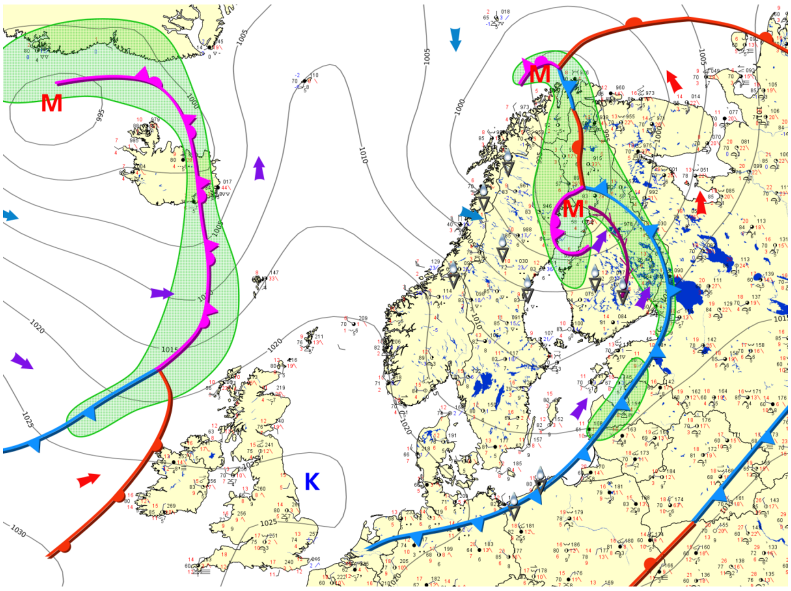

Figure 6. 23 May 2015 12 UTC (Analysis by FMI)

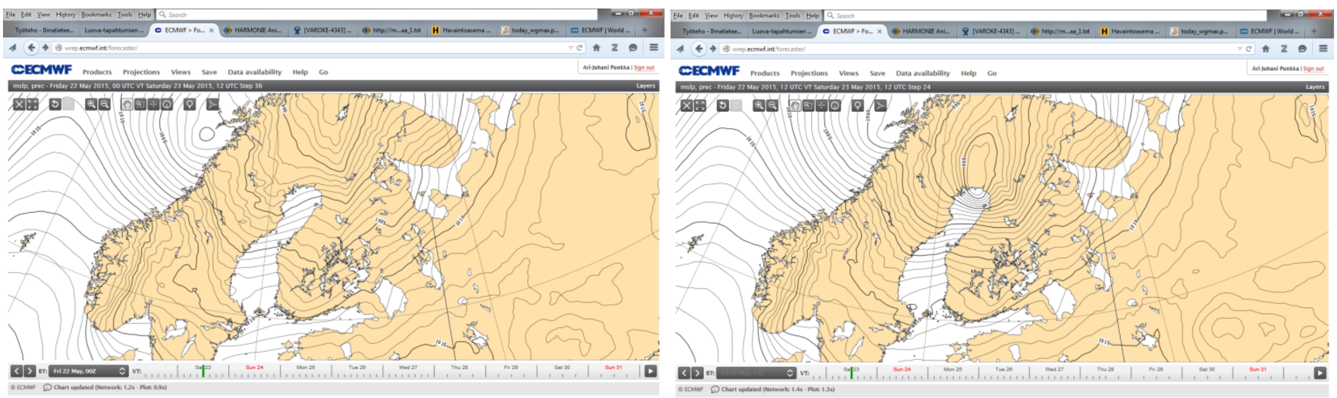

Figure 7. Forecasted mslp for 23 May 2015 12 UTC.
Left: model run 22 May 2015 00 UTC
Right: model run 22 May 2015 12UTC

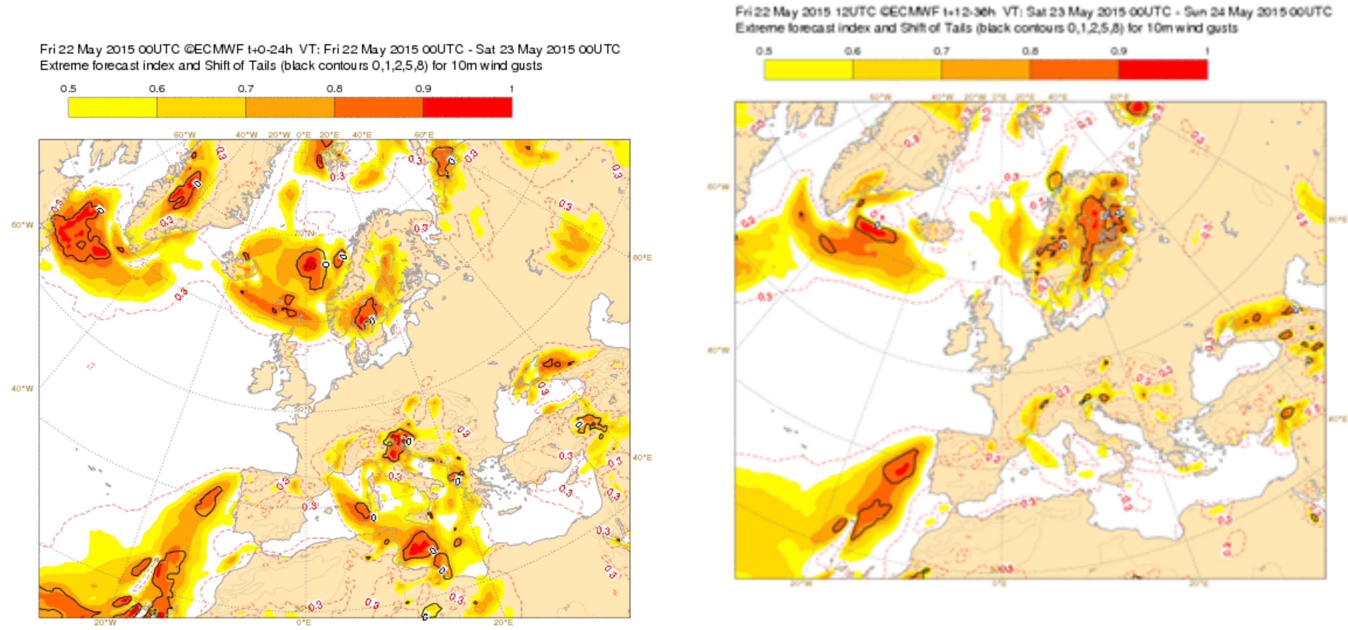

Figure 8. Extreme forecast index and shift of tails. a) Forecast basetime 22 May 2015 00UTC. Faint signal over Western Finland. b) Forecast basetime 22 May 2015 12UTC. The first model run showing a strong signal.

3 June 2015:

Positive feedback: A similar storm occurred on 3 June 2015 and this time the forecasts were better.